

WHAT IS CLAIMED IS:

1. A lens system comprising;  
a plurality of lenses, a stop, and a diffractive  
surface,

5 said lens system moving the whole or part of the  
lens system during focusing and satisfying the  
following condition:

$$\beta \geq 0.5,$$

where  $\beta$  is a maximum photographic magnification.

10 2. The lens system according to Claim 1, wherein  
part of the lens system moves during focusing, and said  
a plurality of lenses is arranged symmetric or  
substantially symmetric with respect to said stop.

15 3. The lens system according to Claim 1, wherein  
said diffractive surface consists of a diffraction  
grating rotationally symmetric with respect to the  
optical axis,

20 wherein when the phase  $\phi(h)$  of said diffraction  
grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

25 where  $\lambda$  is an arbitrary wavelength in the visible  
region,  $Ci$  aspheric phase coefficients, and  $h$  a height  
from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

4. The lens system according to Claim 1, which satisfies the following condition:

$$|\Delta S/f| > 1.0,$$

where  $\Delta S$  is a maximum moving distance of the whole of said lens system during focusing from an object at infinity to an object at a near distance, and  $f$  a focal length of the entire lens system.

5. A lens system comprising;

a diffractive surface, and

a first lens unit of a positive refracting power, a stop, and a second lens unit of a positive refracting power in the order (named) from the object side,

said lens system moves the whole of the lens system during focusing and changes air spaces before and after said stop during focusing.

6. The lens system according to Claim 5, which satisfies the following condition:

$$0.7 < |\Delta s_1/\Delta s_2| < 1.3,$$

where  $\Delta s_1$  is a moving distance of said first lens unit during focusing and  $\Delta s_2$  a moving distance of said second lens unit during focusing.

7. The lens system according to Claim 5, which satisfies the following conditions:

$$0.7 < f_1/f < 1.3, \text{ and}$$

2241	2242	2243	2244	2245	2246	2247	2248	2249	2250	2251	2252	2253	2254	2255	2256	2257	2258	2259	2260	2261	2262	2263	2264	2265	2266	2267	2268	2269	2270	2271	2272	2273	2274	2275	2276	2277	2278	2279	2280	2281	2282	2283	2284	2285	2286	2287	2288	2289	2290	2291	2292	2293	2294	2295	2296	2297	2298	2299	2300	2301	2302	2303	2304	2305	2306	2307	2308	2309	2310	2311	2312	2313	2314	2315	2316	2317	2318	2319	2320	2321	2322	2323	2324	2325	2326	2327	2328	2329	2330	2331	2332	2333	2334	2335	2336	2337	2338	2339	2340	2341	2342	2343	2344	2345	2346	2347	2348	2349	2350	2351	2352	2353	2354	2355	2356	2357	2358	2359	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381	2382	2383	2384	2385	2386	2387	2388	2389	2390	2391	2392	2393	2394	2395	2396	2397	2398	2399	2400	2401	2402	2403	2404	2405	2406	2407	2408	2409	2410	2411	2412	2413	2414	2415	2416	2417	2418	2419	2420	2421	2422	2423	2424	2425	2426	2427	2428	2429	2430	2431	2432	2433	2434	2435	2436	2437	2438	2439	2440	2441	2442	2443	2444	2445	2446	2447	2448	2449	2450	2451	2452	2453	2454	2455	2456	2457	2458	2459	2460	2461	2462	2463	2464	2465	2466	2467	2468	2469	2470	2471	2472	2473	2474	2475	2476	2477	2478	2479	2480	2481	2482	2483	2484	2485	2486	2487	2488	2489	2490	2491	2492	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503	2504	2505	2506	2507	2508	2509	2510	2511	2512	2513	2514	2515	2516	2517	2518	2519	2520	2521	2522	2523	2524	2525	2526	2527	2528	2529	2530	2531	2532	2533	2534	2535	2536	2537	2538	2539	2540	2541	2542	2543	2544	2545	2546	2547	2548	2549	2550	2551	2552	2553	2554	2555	2556	2557	2558	2559	2560	2561	2562	2563	2564	2565	2566	2567	2568	2569	2570	2571	2572	2573	2574	2575	2576	2577	2578	2579	2580	2581	2582	2583	2584	2585	2586	2587	2588	2589	2590	2591	2592	2593	2594	2595	2596	2597	2598	2599	2600	2601	2602	2603	2604	2605	2606	2607	2608	2609	2610	2611	2612	2613	2614	2615	2616	2617	2618	2619	2620	2621	2622	2623	2624	2625	2626	2627	2628	2629	2630	2631	2632	2633	2634	2635	2636	2637	2638	2639	2640	2641	2642	2643	2644	2645	2646	2647	2648	2649	2650	2651	2652	2653	2654	2655	2656	2657	2658	2659	2660	2661	2662	2663	2664	2665	2666	2667	2668	2669	2670	2671	2672	2673	2674	2675	2676	2677	2678	2679	2680	2681	2682	2683	2684	2685	2686	2687	2688	2689	2690	2691	2692	2693	2694
------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------	------

5

10

15

$C1 < 0$  and  $C2 > 0$ .

25

10. A lens system comprising;

a diffractive surface, and

a first lens unit of a positive refracting power,  
a second lens unit of a positive refracting power, and  
a lens unit of a negative refracting power closest to  
an image, in the order (named) from the object side,

wherein during focusing from an object at infinity  
to an object at a near distance said first lens unit  
and said second lens unit move toward the object side  
and an air space increases on the said object side from  
said lens unit of the negative refracting power.

11. The lens system according to Claim 10, which  
satisfies the following condition:

$$0.7 < |\Delta s1/\Delta s2| < 1.3,$$

where  $\Delta s1$  is a moving distance of said first lens  
unit during focusing and  $\Delta s2$  a moving distance of said  
second lens unit during focusing.

12. The lens system according to Claim 10, which  
satisfies the following conditions:

$$0.6 < f1/f < 1.1,$$

$$1.5 < f2/f < 3.5, \text{ and}$$

$$-6.0 < fR/f < -2.0,$$

where  $f1$  is a focal length of said first lens  
unit,  $f2$  a focal length of said second lens unit,  $fR$  a  
focal length of said lens unit of the negative  
refracting power, and  $f$  a focal length of the entire

Year	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100
1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052	2053	2054	2055	2056	2057	2058	2059	2060	2061	2062	2063	2064	2065	2066	2067	2068	2069	2070	2071	2072	2073	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084	2085	2086	2087	2088	2089	2090	2091	2092	2093	2094	2095	2096	2097	2098	2099	2100	

16. The lens system according to Claim 10,  
wherein said lens unit of the negative refracting power  
is fixed during the focusing.

17. The lens system according to Claim 10, which satisfies the following condition:

$$|\Delta s_1/f| > 1.0,$$

where  $\Delta s_1$  is a moving distance of the first lens unit during said focusing and  $f$  a focal length of the entire lens system.

18. A lens system comprising;

a diffractive surface, and

a first lens unit of a positive refracting power and a second lens unit of a negative refracting power in the order (named) from the object side,

wherein during focusing from an object at infinity to an object at a near distance, said first lens unit moves toward said object side and a spacing increases between said first lens unit and said second lens unit.

19. The lens system according to Claim 18, which satisfies the following conditions:

$$0.5 < f_1/f < 1.1, \text{ and}$$

$$-2.5 < f_2/f < -1.5,$$

where  $f_1$  is a focal length of said first lens unit,  $f_2$  a focal length of said second lens unit, and  $f$  a focal length of the entire lens system.

20. The lens system according to Claim 18, wherein said first lens unit comprises a diffractive

surface.

21. The lens system according to Claim 18,  
wherein said diffractive surface consists of a  
5 diffraction grating rotationally symmetric with respect  
to the optical axis,

wherein when the phase  $\phi(h)$  of said diffraction  
grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda * (C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

10 where  $\lambda$  is an arbitrary wavelength in the visible  
region,  $Ci$  aspheric phase coefficients, and  $h$  a height  
from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

15

22. The lens system according to Claim 18,  
wherein said second lens unit is fixed during the  
focusing.

20

23. A lens system comprising;  
a diffractive surface, and

a first lens unit of a positive refracting power  
and a second lens unit of a positive refracting power  
in the order (named) from the object side,

25

wherein during focusing from an object at infinity  
to an object at a near distance, said first lens unit  
moves toward the object side.

240  
Cont'd

240  
Cont'd

$0.7 \leq f_1/f < 1.3$ , and

5           where  $f_1$  is a focal length of said first lens  
unit,  $f_2$  a focal length of said second lens unit, and  $f$   
a focal length of the entire lens system.

10

15

20

where  $\lambda$  is an arbitrary wavelength in the visible region,  $C_i$  aspheric phase coefficients, and  $h$  a height from the optical axis,

**C1 < 0 and C2 > 0.**

27. The lens system according to Claim 23,  
wherein said second lens unit is fixed during the

focusing.

28. A lens system comprising;

a diffractive surface, and

5 a first lens unit of a positive refracting power,  
a second lens unit of a negative refracting power, and  
a third lens unit of a positive refracting power in the  
order (named) from the object side,

10 wherein during focusing from an object at infinity  
to an object at a near distance, said first lens unit  
is fixed, said second lens unit moves toward an image  
side, and said third lens unit moves toward the object  
side.

15 29. The lens system according to Claim 28, which  
satisfies the following condition:

$$0.50 < \Delta s_2 / |\Delta s_3| < 1.50,$$

20 where  $\Delta s_2$  is a moving distance of said second lens  
unit during the focusing and  $\Delta s_3$  a moving distance of  
said third lens unit during the focusing.

30. The lens system according to Claim 28, which  
satisfies the following conditions:

$$0.40 < f_1/f < 0.65,$$

25  $-0.50 < f_2/f < -0.25,$  and

$$0.40 < f_3/f < 1.10,$$

where  $f_1$  is a focal length of said first lens

unit,  $f_2$  a focal length of said second lens unit,  $f_3$  a focal length of said third lens unit, and  $f$  a focal length of the entire lens system.

240  
Cont'd

5           31. The lens system according to Claim 28, wherein said diffractive surface consists of a diffraction grating rotationally symmetric with respect to the optical axis,

10           wherein when the phase  $\phi(h)$  of said diffraction grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda * (C_1 h^2 + C_2 h^4 + C_3 h^6 + \dots + C_i h^{2i}),$$

where  $\lambda$  is an arbitrary wavelength in the visible region,  $C_i$  aspheric phase coefficients, and  $h$  a height from the optical axis,

15           the following conditions are satisfied:

$$C_1 < 0 \text{ and } C_2 > 0.$$

20           32. The lens system according to Claim 28, wherein said first lens unit comprises a positive lens closest to the object.

25           33. The lens system according to Claim 28, wherein a stop is placed between said second lens unit and said third lens unit and said stop is fixed during the focusing.

34. The lens system according to Claim 28, which

comprises a flare cut stop in the optical path.

35. The lens system according to Claim 28, wherein said second lens unit and said third lens unit both comprise their respective cemented lenses.

36. A lens system comprising;  
a diffractive surface, and  
a first lens unit of a positive refracting power,  
a second lens unit of a negative refracting power, a  
third lens unit of a positive refracting power, and a  
fourth lens unit of a negative refracting power in the  
order (named) from the object side,

wherein during focusing from an object at infinity  
to an object at a near distance, the first lens unit is  
fixed, said second lens unit moves toward an image  
side, and said third lens unit moves toward the object  
side.

37. The lens system according to Claim 36, which  
satisfies the following condition:

$$0.50 < \Delta s_2 / |\Delta s_3| < 1.50,$$

where  $\Delta s_2$  is a moving distance of said second lens  
unit during the focusing and  $\Delta s_3$  a moving distance of  
said third lens unit during the focusing.

38. The lens system according to Claim 36, which

satisfies the following conditions:

$$0.40 < f_1/f < 0.70,$$

$$-0.45 < f_2/f < -0.25,$$

$$0.25 < f_3/f < 0.55, \text{ and}$$

$$-1.0 < f_4/f < -0.4,$$

where  $f_1$  is a focal length of said first lens unit,  $f_2$  a focal length of said second lens unit,  $f_3$  a focal length of said third lens unit,  $f_4$  a focal length of said fourth lens unit, and  $f$  a focal length of the entire lens system.

39. The lens system according to Claim 36, wherein said first lens unit comprises a positive lens closest to the object.

40. The lens system according to Claim 36, wherein a stop is placed between said second lens unit and said third lens unit and said stop is fixed during the focusing.

41. The lens system according to Claim 36, which comprises a flare cut stop in the optical path.

42. The lens system according to Claim 36, wherein said second lens unit and said third lens unit both comprise their respective cemented lenses.

43. The lens system according to Claim 36,  
wherein said diffractive surface consists of a  
diffraction grating rotationally symmetric with respect  
to the optical axis,

5 wherein when the phase  $\phi(h)$  of said diffraction  
grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda*(C1*h^2 + C2*h^4 + C3*h^6 + \dots + Ci*h^{2i}),$$

where  $\lambda$  is an arbitrary wavelength in the visible  
region,  $Ci$  aspheric phase coefficients, and  $h$  a height  
10 from the optical axis,

the following conditions are satisfied:

$$C1 < 0 \text{ and } C2 > 0.$$

44. A lens system comprising;

15 a diffractive surface, and

a first lens unit of a positive refracting power,  
a second lens unit of a negative refracting power, a  
third lens unit of a positive refracting power, and a  
fourth lens unit of a positive refracting power in the  
20 order (named) from the object side,

wherein during focusing from an object at infinity  
to an object at a near distance, the first lens unit is  
fixed, said second lens unit moves toward an image  
side, and said third lens unit moves toward the object  
25 side.

45. The lens system according to Claim 44, which

240  
Continued

11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50

satisfies the following condition:

$$0.50 < \Delta s_2 / |\Delta s_3| < 4.00,$$

where  $\Delta s_2$  is a moving distance of said second lens unit during the focusing and  $\Delta s_3$  a moving distance of said third lens unit during the focusing.

46. The lens system according to Claim 44, which satisfies the following conditions:

$$0.20 < f_1/f < 0.60,$$

$$-0.50 < f_2/f < -0.10,$$

$$0.50 < f_3/f < 1.50, \text{ and}$$

$$0.70 < f_4/f < 1.80,$$

where  $f_1$  is a focal length of said first lens unit,  $f_2$  a focal length of said second lens unit,  $f_3$  a focal length of said third lens unit,  $f_4$  a focal length of said fourth lens unit, and  $f$  a focal length of the entire lens system.

47. The lens system according to Claim 44, wherein said diffractive surface consists of a diffraction grating rotationally symmetric with respect to the optical axis,

wherein when the phase  $\phi(h)$  of said diffraction grating is given by the following equation:

$$\phi(h) = 2\pi/\lambda * (C_1 * h^2 + C_2 * h^4 + C_3 * h^6 + \dots + C_i * h^{2i}),$$

where  $\lambda$  is an arbitrary wavelength in the visible region,  $C_i$  aspheric phase coefficients, and  $h$  a height

from the optical axis,

the following conditions are satisfied:

$C1 < 0$  and  $C2 > 0$ .

240  
Cont'd

5           48. The lens system according to Claim 44,  
wherein during the focusing, said fourth lens unit is  
fixed relative to the image plane.

10           49. The lens system according to Claim 44, which  
comprises a stop in the optical path, wherein said stop  
is fixed during the focusing.

15           50. The lens system according to Claim 44, which  
comprises a flare cut stop in the optical path.

20           51. An optical device comprising;  
the lens system of Claim 1, and  
a housing which holds said lens system.

25           52. An optical device comprising;  
the lens system of Claim 5, and  
a housing which holds said lens system.

          53. An optical device comprising;  
the lens system of Claim 10, and  
a housing which holds said lens system.

240  
Conc'd

5

54. An optical device comprising;  
the lens system of Claim 18, and  
a housing which holds said lens system.

55. An optical device comprising;  
the lens system of Claim 23, and  
a housing which holds said lens system.

10

56. An optical device comprising;  
the lens system of Claim 28, and  
a housing which holds said lens system.

15

57. An optical device comprising;  
the lens system of Claim 36, and  
a housing which holds said lens system.

58. An optical device comprising;  
the lens system of Claim 44, and  
a housing which holds said lens system.